tempts to make for the Experiment Station Record. The ninth volume of the Record contains 1,100 pages of text, of which 770 pages are taken for abstracts of publications originally occupying 56,569 pages. In addition to this, the volume contains 2,471 titles of articles, with brief abstracts in some cases. The index of names for this volume fills 15 pages printed in nonpareil type in three columns; the index of subjects fill 80 pages printed in the same type in two columns.

Now that ten volumes of the Record have been completed, the question of making a general index to cover them has been raised. If such an index can be provided for at intervals of ten years it is believed that this and the annual indexes with a set of the Record will constitute an instrument for ready reference to the literature of agricultural science much more convenient and effective for the uses of the specialist than any card index can be.

A. C. True.

Washington, D. C., October 23, 1899.

SCIENTIFIC BOOKS.

West Virginia Geological Survey. Volume I. By I. C. White, State Geologist, Morgantown, W. Va. 1899. 8vo. 392 pp. Map.

Dr. White was commissioned as State Geologist in 1897 and began work in the autumn of that year. This first volume gives only a portion of the material accumulated prior to the close of 1898, as the appropriation for printing was very small. Political complications during the session of 1899 hindered legislation and the survey work will remain suspended until after the next session of the Legislature.

At the time this survey was undertaken, the all-absorbing matter of economic interest was that of oil and gas, with which Part IV. of the report, occupying 270 pages, deals. The historical sketch of discovery, methods and utilization of oil and gas in the State is followed by a discussion of the geology of those products, treating of method of occurrence; quantity to the acre; aids in location; anticlinal theory; relation of oil and gas to structure; and other topics full of interest, viewed from the standpoint either of pure science or economics. The anticlinal or structural theory of the occurrence of oil and gas, presented by Dr. White many years ago, is elaborated here in the light of developments made in the Ohio and West Virginia fields. Though leading to slight modification of statements made when the theory was rather suggested than asserted, these severe experimental tests have rendered necessary no material changes, but on the contrary have shown that the theory was but the expression of a law. One cannot give a synopsis of the discussion for that is itself a model of condensation. It possesses much interest not only for the student of economic geology, but also for those geologists who find little that is attractive in matters relating to economic interests.

The general section through which wells have been drilled is described. It extends from the Permo-Carboniferous to the Corniferous limestone, a total of 7,200 feet, a thickness contrasting notably with that in south central Pennsylvania, where the upper Devonian alone (the Chemung and the Catskill of Vanuxem) is as great. The records of 104 wells drilled in different parts of the State are discussed in detail, compared with each other and with localities where the rocks are exposed. These wells are from 1,000 to more than 4,000 feet deep. The labor involved in working up the bald records into intelligible sections, of identifying the several coal beds and the subordinate sands, can hardly be conceived by those who have not done such work; the more so, since necessarily the published records form but a small part of those studied in order make the comparisons conclusive. The writer in the course of a study, still in progress, tabulated all these records given by Dr. White to compare them with results obtained by other observers in West Virginia, Ohio and Pennsylvania. Out of all the many points at which the several sets of observations came together, only two were found where it seemed impossible to accept Dr. White's conclusions—and in one of these Dr. White proved to be right.

This volume is a contribution so important that one cannot fail to regret the neglect of the

Legislature which has prevented publication of the volume on coal. That interest, owing to the sudden expansion of iron manufacture, is now paramount, and the state is losing enormously by this failure to publish the material accumulated by Dr. White in extended reconnaissances during the last ten years. To those engaged in investigating the serious problems presented by the Carboniferous, the inaccessibility of this material is a misfortune.

The map shows the oil fields and productive areas of the several coal series. The limits of the Pittsburg, as determined by borings, differ from the Rogers lines as much for West Virginia as for Ohio. The geographical conditions during the formation of that bed were evidently very unlike those suggested by the older geologists.

The abundance of typographical errors is evidence that the author had no opportunity to correct the proofs, and reminds the writer of his own experience with the West Virginia State Printer almost thirty years ago, when Mr. F. B. Meek and he were made chargeable with statements which afforded some annoyance to them and much amusement to their acquaintances.

JOHN J. STEVENSON.

Introduction à la géométrie différentielle suivant la méthode de H. GRASSMAN. Par C. Burali-Forti, professeur à l'Académie militaire de Turin. Paris, Gauthier-Villars. 1897. 8vo. Pp. xi + 165.

This volume contains a brief exposition of the geometrical calculus and some of its applications to elementary differential geometry.

The analytical geometry of Descartes (1637), operates on numbers which have an indirect relation with the geometrical elements which they represent. Leibnitz* in 1679 recognized the advantages of a geometrical calculus operating directly on geometrical elements, but the operation suggested by Leibnitz does not possess the ordinary properties of algebraic operations. The idea, however, was fruitful, and in 1797 Caspar Wessel† gave an analytical representation of direction which contains Argand's (1806) geometrical interpretation of complex numbers and several of the operations introduced by Hamilton (1843–1854) in his method of quaternions. Later the barycentric calculus (1827–1842) of Möbius and the method of equipollences (1832–1854) of Bellavitis brought forward two independent methods of geometric calculus which their authors applied to various questions of geometry and mechanics. In 1843 Hamilton published his first essay on quaternions; the complete development of this theory in 1854 gives a complete geometrical calculus which finds at present its most extensive applications in mathematical physics. The works of Hamilton were preceded by the Ausdehnungslehre (1844), of H. Grassmann which, in the power and simplicity of its operations, surpasses all other known forms of geometrical calculus. The method of exposition adopted by Grassmann is exceedingly abstract and this fact has stood stubbornly in the way of the general adoption of the Ausdehnungslehre to such an extent that we use to-day the bar
tric calculus, the theory of equipollences, quaternions, or the Cartesian geometry, for the resolution of geometric questions which are capable of much more simple resolution by the methods of Grassmann. These classic objections to Grassmann's exposition have been met recently by Peano* who has given concrete geometric interpretations to the forms and operations of the Ausdehnungslehre. There is a splendid account of the importance of this discipline in geometry, mechanics and physics to be found in the historical memoir of Schlegel.†

M. Burali-Forti gives the elements of Grassmann's calculus as reconstructed by Peano. The latter took the idea of a tetrahedron as his starting point and defined the product of two and three points; he then defined the products of these elements by numbers and finally gave definitions of the sums of these products. The theory of forms of the first order gives the barycentric calculus and that of vectors; the geometric forms of the second order represent straight lines, orientations, and systems of forces

* Leibnitz, *Math. Schriften*, II., V., Berlin, 1849.

† Caspar Wessel, Om Directionens analytiske Betegning, March 10, 1797; published by the Denmark Academy of Sciences, Copenhagen, 1897.

* Peano, Calcolo geometrico, Turin, 1888.

† Schlegel, Die Grassmann'sche Ausdehnungslehre, *Zeitschrift für Math. und Physik*, 1896.